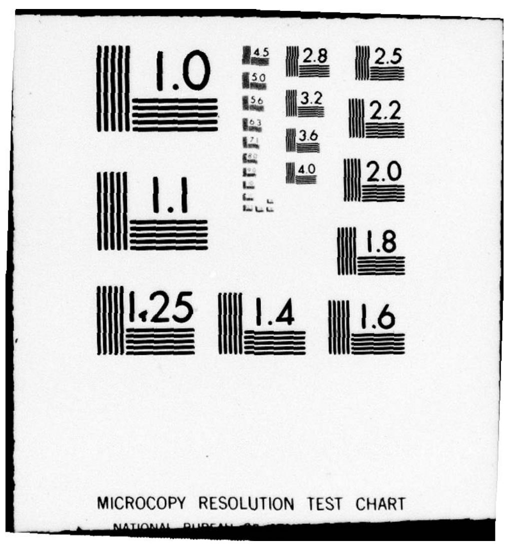
AD-A074 966 NAVAL RESEARCH LAB WASHINGTON DC F/G 20/7
REPORT OF CYCLOTRON FACILITY OPERATIONS OCTOBER 1, 1978 THROUGH--ETC(U)
SEP 79 R O BONDELID PHS-NCI-1Y-CO-4000-000
UNCLASSIFIED NRL-MR-4090 NL

1 OF 1
AD A
074966

END
DATE
FILMED
11 -79
DDC


1.0
4.5
5.0
5.6
6.3
2.8
2.5
3.2
2.2
3.6
4.0
2.0
1.1
1.8
1.25
1.4
1.6
MICROCOPY RESOLUTION TEST CHART

LEVEL IV

NRL Memorandum Report 4090

Report of Cyclotron Facility Operations October 1, 1978 through June 30, 1979

Rollon O. Bondelid

Cyclotron Applications Branch
Radiation Technology Division

September 28, 1979

NAVAL RESEARCH LABORATORY
Washington, D.C.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
NRL Memorandum Report 4090

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
6
REPORT OF CYCLOTRON FACILITY OPERATIONS OCTOBER 1, 1978 THROUGH JUNE 30, 1979 .

5. TYPE OF REPORT & PERIOD COVERED
Interim report on a continuing NRL problem.

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
10 Rollon O. Bondelid

14 NRL-MR-4090

8. CONTRACT OR GRANT NUMBER(s)
15 PHS ~~NIH~~NCI-1Y-CO-4000-000 ok
0 H01-23A

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Naval Research Laboratory
Washington, DC 20375

16 RRØ12Ø2

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
17
61153N-12 RR012-02-41
(Continues)

11. CONTROLLING OFFICE NAME AND ADDRESS
Department of the Navy
Office of Naval Research
Washington, DC 20375

12 15

12. REPORT DATE
11 28 Sep[redacted]79

13. NUMBER OF PAGES
14

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

9 Quarterly rept. no. 7, Sep - 3Ø Jun 79,

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Patty Scott

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Neutron fields	Radioisotopes	Dosimetry
Neutron spectrum	Shielding	Fast neutrons
Weapons effects	Proportional counters	Radiation effects
Reactor materials	Linear energy transfer	Positive ion beams

(Continues)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is the seventh in a series of quarterly reports summarizing the use of the Naval Research Laboratory Cyclotron Facility. During the nine month period ending June 30, 1979 the cyclotron was used in support of eight research programs for a total 1325 hours of beam on target. These research programs are summarized in this report together with the details of beam time usage and facility engineering. No major operational problems ~~have been~~ were encountered this year.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

251 950

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

mt

10. **Program Element, Project, Task Area & Work Unit Numbers (Continued)**

NRL Problem H00-01
H01-57
H01-79
H01-83
H01-94
H11-01
H11-07
H11-08

19. **Key Words (Continued)**

Neutron beams
Nuclear reactor
Neutron production
Non-military application
Cancer treatment

CONTENTS

I. Introduction

The Naval Research Laboratory Cyclotron Facility began operations as a cost center on October 1, 1977 and completed the first year of such operation on September 30, 1978. For fiscal year 1979 an estimate was made of the projected cost of operating the cyclotron facility and the number of hours users would require the cyclotron beam. These estimates are $273,200 and 2024 hours respectively, leading to a charge of $135 per hour. This report is the seventh in the current series of quarterly reports covering operation of the NRL Cyclotron Facility as a cost center from October 1, 1978 through June 30, 1979.

II. Beam Time Records

A. The Daily Record

Beam time charge accounting is accomplished using a simple method of coding information. At the end of each week the information is recorded in card images and stored on the disc file of the Systems 32/55 data acquisition computer located in the Cyclotron Facility for later recall and summarization. Figure 1 in the first report of this series is a sample of a beam time code sheet. The method of using this form was also described in the first report.

B. Computer Readout

Tables 1 through 4 show the collated data from the beam time card images.

Table 1 shows the beam time use by program and month. Outage is listed as a point of interest. This table is submitted to the NRL budget branch at the end of each month. Proper charges can then be recorded against the using program and credited to the cyclotron cost center.

Table 2 shows the summary by program and particle. The lowest and highest energies for that particle used are also shown.

Table 3 shows the beam time summaries in various ways. Firstly, by program, secondly, by month and thirdly, by particle. Clearly, the table shows that the greatest user has been the MANTA program.

Table 4 is an overall summary of beam time which lists primarily the reasons for unscheduled outages. From this table we see the major problem source continues to be the power supplies of the cyclotron. However, the R. F. system of the cyclotron has developed problems which has caused some significant down time. Outage number 8, "Experimenters Equipment," is included in total beam-on time, but it is not included as cyclotron down time. The item, "Total Hours Available to Date," is the number of hours from 0000 hours October 1 through 2400

Note: Manuscript submitted August 7, 1979

hours June 30. The NRL cyclotron schedule had originally been planned for operating two 8-hour shifts per day for six days per week, holidays and scheduled engineering periods excluded. The utilization factor is the total scheduled time divided by this planned schedule.

III. Engineering and Maintenance

A. Cyclotron

A remotely operable particle detector positioner was installed at the terminal end of Beam-Line 1C. The device has an adjustable, reversible speed drive. It allows precision horizontal positioning of detectors in straight-line motion along the ion-beam-line axis in two directions, with negligible wobble, within a range of 10 cm to 150 cm from the target being irradiated. Initial alignment is done using a laser beam. Readouts and controls are located in the data acquisition room at the physicists' work station.

An updated phase sensing and control circuit to electronically stabilize the cyclotron's magnetic field has been bread boarded and tested using three NIM bins for amplification and detection. Work is continuing on debugging and improving the prototype. The pending acquisition of a fast detector to pick up the capacitive, beam-probe signal will eliminate the need for the NIM bins.

For the type of operation conducted in the cyclotron facility, it is essential that equipment be shut down and overhauled in the shortest possible time. To permit continuous operation of the cyclotron while concurrently doing maintenance, the transistor banks (an average of 10 banks each having 29 power transistors) were bypassed by shorting across the common emitter and collector busses and disconnecting the transistor drive signal. A small, regulated dc Kepco power supply was substituted for the transistor banks to drive the SCR's, thus controlling the output current. To provide remote control of the supply from the Cyclotron Control Room, a circuit, using a Zener diode for protection, was designed and installed between the small power supply and the SCR firing circuit. Although some slow drift of a few dc amps occurred (3500 amps is average operating current), it can be operator-corrected without noticeable ion-beam degradation.

IV. Summary of Facility Use

A. MANTA

Six patients were in various stages of treatment during this reporting period. See the previous reports in this series for a further discussion of the neutron therapy program. The National Cancer Institute terminated the MANTA program effective June 30, 1979.

A'. MANTA Dosimetry

Clinical research continued on whole-body dosimetry for open and wedged fields. These measurements are taken in a Rando-anthropomorphic phantom and in tissue-equivalent liquid phantoms by means of diodes, ion chambers, foil activation and thermoluminescent dosimeters. These four types of dosimeters are used in an attempt to separate whole-body dose into fast-neutron, thermal-neutron and gamma components.

During this period two runs were made on a collaborative experiment with Dr. Richard Miller of Columbia University to compare the relative biological effectiveness of neutrons with x-rays for the induction of onocogenic cell transformations.

Two one-week runs were made in continuation of an experiment involving mouse tumor systems performed in collaboration with Professor Herman Suit of Massachusetts General Hospital and Harvard University. Each run is a set of five-fraction treatments, one per day for five days. The object is to compare tumor response and normal tissue reactions for neutron treatment, x-ray treatment, and x-ray treatment in conjunction with hypoxic sensitizers or hypobaric oxygen.

B. Advanced Microdosimetry

As indicated under the Neutron Spectrometer Section of this report, the recently discovered light-ion flux associated with collimated neutron beams can influence the results obtained in the advanced microdosimetry program. Accordingly, some time was spent studying the light-ion flux under this work unit.

At the end of this reporting period the stainless-steel Rossi counter and some associated equipment were received, and preparatory work has begun for using this novel instrument.

Progress has been made during this reporting period in developing Systems computer software and hardware for acquiring and analyzing the Rossi-counter data. The implementation of the needed live-time correction feature on the Systems computer awaits final check out.

C. Radiation Interactions

Dynamic 16K random access memories (RAMs) have been irradiated with neutrons having mean energies of 6.5, 9 and 14 MeV and with 32 MeV protons and have been found to undergo single-event upset. For both particles, one upset is expected for approximately 10^8 particles/cm^2. The upsets are statistical and the affected cells can be reset and continue normal operation. Both HIGH and LOW storage elements are upset, though at different rates. The cause of the upsets is most

probably a multi-MeV alpha particle created by (n, alpha), (p, alpha) or similar nuclear reactions. The alpha particle discharges either the storage capacitor, the floating bit line, or the reference capacitor used by the sense amplifier.

A total of 15 dynamic RAMs from five vendors were irradiated, namely, Intel C2117-2, Motorola MCM4116L20, Texas Instrument TMS4116-200L, Hitachi HM4716A-3 and NEC PD416D. All were tested at a cyclotron mean neutron energy of 14 MeV. Selected ones were also irradiated at cyclotron neutron energies of 9 MeV and 6.5 MeV or d-t neutrons of 14-MeV energy. Two chips were irradiated with 32-MeV protons. In each case both the '0' and '1' memory states were tested.

The numbers given for upset levels are the mean fluence for a single upset in one 16K RAM. A moderate size computer memory of 64K bytes requires 32 of the 16K RAMs. The mean fluence for one upset in the memory then drops from say 2×10^8 n/cm^2 to 6×10^6 n/cm^2. If a 90% confidence of no upset is required, the acceptable neutron fluence drops to 6×10^5 n/cm^2. These levels for upset are many orders of magnitude below the thresholds for commonly tested neutron damage.

D. Neutron Damage

A set of commercial LED devices previously selected by Deep Level Transient Spectroscopy (DLTS) to have similar pre-irradiation characteristics have been irradiated by a 14-MeV neutron beam. These devices are being analyzed by DLTS to see the effects of the neutron beam.

E. Neutron Spectrometer

During this reporting period measurements were made that showed there is a significant energetic, light-ion flux produced by collimated neutron beams in air. Work is continuing on quantifying this light-ion flux since it can have a significant impact on work done in this program as well as others. A good deal of effort will be required to adequately parameterize this light-ion flux. Our results on this light-ion flux are to be presented at the APS Meeting to be held in Knoxville, Tennessee in October 1979.

F. Neutron Spectra

Some data were acquired for the (n, charged particle) spectrum produced by the neutron beam in air. A strong peak due to deuterons passing through feed-throughs in the Beryllium target assembly was identified and eliminated with shielding. A remotely controlled assembly for locating the detector at distances of 10 cm to 110 cm from the target

was installed. This assembly enables the identification of fluxes from the Al end plate of the target assembly to be followed in air and separated from the flux produced in air.

The Systems Computer software support systems were changed to RTM 7.0 and TSS 3.0. These systems have a number of valuable enhancements. The data transmission rate to the terminals was increased during this installation. The data acquisition system was modified to run with the new support system.

F. Heavy Ion Acceleration

A few computer runs, using the program DIAL, have been made for the heavy ions $^{14}N^{4+}$ and $^{14}N^{5+}$. For calculations under the present running conditions (trim coils 1 and 3 = 0, and no harmonic coils), the RMS field errors are quite large, though they decrease with increasing ion energy. Possibly the isochronous field for a 100.5 MeV $^{14}N^{5+}$ beam could be obtained under present conditons. With optimum running conditions (maximum of all trim coils = 800 amps and harmonic coils working) there should be no trouble in obtaining the isochronous fields needed for the heavy-ion beams.

V. Accounting

Estimates made at the beginning of the fiscal year were for a total beam time of 2024 hours in support of the various programs. The total budget required to support this beam time is estimated to be $273,200. On a straight line extrapolation this would lead to 1518 hours of beam time and a budget of $204,900 for the nine month period ending June 30. The actual beam time use during this period was 1325 hours which represents a cost transfer of $178,900. The job order status report through 30 June showed total costs of $199,300. At this time the cost center is running about $20,000 dollars behind income. Although the MANTA program is no longer active and providing income to the cost center, other programs have increased in activity and it is expected that cyclotron use will not drop significantly. Current cost projections indicate that the total budget will be less than that estimated at the beginning of the year by 15 to 20 k$.

Table 5 shows a list of purchases required for Cyclotron Facility operation. The table is self explanatory.

VI. Conclusion

The NRL Cyclotron Facility continues to operate effectively as a cost center. Costs will come close to matching income and the use of the facility will not be far from that which was predicted at the start of the fiscal year.

Report Assembled by R. Bondelid

Contributors: **R. Allas**
L. August
C. Davisson
G. Miller
E. Petersen

Table 1

Beam time summary by program and month

CYCLOTRON APPLICATIONS BRANCH SUMMARY OF BEAM TIME
FY-79 JUNE 30, 1979

PROGRAM	MONTH	BEAM TIME	HT COST	OUTAGE
MANTA 66H01-23A	OCTOBER	158.6 HOURS	$ 21411	9.4 HOURS
	NOVEMBER	113.1 HOURS	$ 15269	10.5 HOURS
	DECEMBER	128.6 HOURS	$ 17361	10.3 HOURS
	JANUARY	129.7 HOURS	$ 17510	1.9 HOURS
	FEBRUARY	108.9 HOURS	$ 14702	2.5 HOURS
	MARCH	109.3 HOURS	$ 14756	17.5 HOURS
	APRIL	120.1 HOURS	$ 16214	25.3 HOURS
	MAY	95.9 HOURS	$ 12947	7.7 HOURS
	JUNE	58.1 HOURS	$ 7844	2.3 HOURS
	SUBTOTAL	1022.3 HOURS	$138014	87.4 HOURS
RADIATION INTER. 66H01-57	JANUARY	6.0 HOURS	$ 810	0.0 HOURS
	FEBRUARY	27.0 HOURS	$ 3645	3.0 HOURS
	MARCH	5.5 HOURS	$ 743	9.6 HOURS
	APRIL	15.5 HOURS	$ 2093	0.5 HOURS
	MAY	21.6 HOURS	$ 2916	7.8 HOURS
	JUNE	36.1 HOURS	$ 4874	0.0 HOURS
	SUBTOTAL	111.7 HOURS	$ 15081	20.9 HOURS
NEUTRON SPECTROM. 66H01-79	NOVEMBER	6.0 HOURS	$ 810	2.0 HOURS
	DECEMBER	14.5 HOURS	$ 1958	0.0 HOURS
	MARCH	10.0 HOURS	$ 1350	0.0 HOURS
	JUNE	1.5 HOURS	$ 203	0.0 HOURS
	SUBTOTAL	32.0 HOURS	$ 4321	2.0 HOURS
H + HE IN METALS 66H01-83	OCTOBER	8.0 HOURS	$ 1080	0.0 HOURS
WEAPONS MONITORS 66H01-94	OCTOBER	0.5 HOURS	$ 68	0.0 HOURS
	NOVEMBER	2.3 HOURS	$ 311	0.0 HOURS
	DECEMBER	4.2 HOURS	$ 567	0.0 HOURS
	FEBRUARY	4.3 HOURS	$ 581	0.0 HOURS
	SUBTOTAL	11.3 HOURS	$ 1527	0.0 HOURS
NEUTRON DAMAGE 66H11-01	OCTOBER	1.0 HOURS	$ 135	0.0 HOURS
	DECEMBER	16.7 HOURS	$ 2255	0.0 HOURS
	JANUARY	12.2 HOURS	$ 1647	0.0 HOURS
	MARCH	30.1 HOURS	$ 4064	0.0 HOURS
	MAY	32.0 HOURS	$ 4320	0.0 HOURS
	JUNE	7.9 HOURS	$ 1067	0.0 HOURS
	SUBTOTAL	99.9 HOURS	$ 13488	0.0 HOURS
ADVANCED MICRODOS. 66H11-07	JUNE	7.0 HOURS	$ 945	0.5 HOURS
NEUTRON EFFECTS 66H11-08	OCTOBER	1.0 HOURS	$ 135	0.0 HOURS
	NOVEMBER	4.5 HOURS	$ 608	0.0 HOURS
	JANUARY	27.7 HOURS	$ 3740	0.0 HOURS
	SUBTOTAL	33.2 HOURS	$ 4483	0.0 HOURS
	TOTAL	1325.4 HOURS	$178939	110.8 HOURS

Table 2

Beam time summary by program and particle

CYCLOTRON APPLICATIONS BRANCH SUMMARY OF BEAM TIME
FY-79 JUNE 30, 1979

PROGRAM	PARTICLE	BEAM TIME	ENERGY	RANGE-MEV
MANTA 66H01-23A	DEUTERON	1022.3 HOURS	35	35
RADIATION INTER. 66H01-57	PROTON	13.0 HOURS	35	36
	DEUTERON	72.7 HOURS	16	35
	HELIUM-3	26.0 HOURS	22	22
	SUBTOTAL	111.7 HOURS		
NEUTRON SPECTRUM. 66H01-79	DEUTERON	32.0 HOURS	16	35
H + HE IN METALS 66H01-83	ALPHA	8.0 HOURS	36	36
WEAPONS MONITORS 66H01-94	DEUTERON	11.3 HOURS	16	35
NEUTRON DAMAGE 66H11-01	DEUTERON	99.9 HOURS	22	35
ADVANCED MICRODOS. 66H11-07	DEUTERON	7.0 HOURS	35	35
NEUTRON EFFECTS 66H11-08	PROTON	27.7 HOURS	16	18
	DEUTERON	5.5 HOURS	35	35
	SUBTOTAL	33.2 HOURS		
	TOTAL	1325.4 HOURS		

Table 3

Beam time totals by program, month and particle

CYCLOTRON APPLICATIONS BRANCH SUMMARY OF BEAM TIME
FY-79 JUNE 30, 1979

PROGRAM	START UP TIME	BEAM ON TARGET	TOTAL TIME	COST	OUTAGE	SCHEDULED TIME	% ON
MARIA	229.4 HOURS	792.9 HOURS	1022.3 HOURS	$ 138011	87.4 HOURS	1109.7 HOURS	92.1
RADIATION DETER.	23.6 HOURS	88.1 HOURS	111.7 HOURS	$ 15080	20.9 HOURS	132.6 HOURS	84.2
NEUTRON SPECTRUM.	4.8 HOURS	27.2 HOURS	32.0 HOURS	$ 4320	2.0 HOURS	34.0 HOURS	94.1
H + HE IN METALS	1.0 HOURS	7.0 HOURS	8.0 HOURS	$ 1080	0.0 HOURS	8.0 HOURS	100.0
WEAPONS MONITORS	2.9 HOURS	8.4 HOURS	11.3 HOURS	$ 1526	0.0 HOURS	11.3 HOURS	100.0
NEUTRON DAMAGE	13.8 HOURS	86.1 HOURS	99.9 HOURS	$ 13487	0.0 HOURS	99.9 HOURS	100.0
ADVANCED MICRODOS.	0.5 HOURS	6.5 HOURS	7.0 HOURS	$ 945	0.5 HOURS	7.5 HOURS	93.3
NEUTRON EFFECTS	8.0 HOURS	25.2 HOURS	33.2 HOURS	$ 4482	0.0 HOURS	33.2 HOURS	100.0
TOTALS	284.0 HOURS	1041.4 HOURS	1325.4 HOURS	$ 178931	110.8 HOURS	1436.2 HOURS	92.3

MONTH	BEAM TIME	OUTAGE	SCHEDULED TIME	% ON
OCTOBER	169.1 HOURS	9.4 HOURS	178.5 HOURS	94.7
NOVEMBER	125.9 HOURS	12.5 HOURS	138.4 HOURS	91.0
DECEMBER	164.0 HOURS	10.3 HOURS	174.3 HOURS	94.1
JANUARY	175.6 HOURS	1.9 HOURS	177.5 HOURS	98.9
FEBRUARY	140.2 HOURS	5.5 HOURS	145.7 HOURS	96.2
MARCH	154.9 HOURS	27.1 HOURS	182.0 HOURS	85.1
APRIL	135.6 HOURS	25.8 HOURS	161.4 HOURS	84.0
MAY	149.5 HOURS	15.5 HOURS	165.0 HOURS	90.6
JUNE	110.6 HOURS	2.8 HOURS	113.4 HOURS	97.5
TOTALS	1325.4 HOURS	110.8 HOURS	1436.2 HOURS	92.3

PARTICLE	BEAM TIME	ENERGY RANGE-MEV		OUTAGE	SCHEDULED TIME	% ON
PROTON	40.7 HOURS	16	36	0.0 HOURS	40.7 HOURS	100.0
DEUTERON	1250.7 HOURS	16	35	103.0 HOURS	1353.7 HOURS	92.4
HELIUM-3	26.0 HOURS	22	22	7.8 HOURS	33.8 HOURS	76.9
ALPHA	8.0 HOURS	36	36	0.0 HOURS	8.0 HOURS	100.0
TOTALS	1325.4 HOURS			110.8 HOURS	1436.2 HOURS	92.3

Table 4

Beam time summary to show cyclotron performance

CYCLOTRON APPLICATIONS BRANCH SUMMARY OF BEAM TIME
FY-79 JUNE 30, 1979

CYCLOTRON OPERATIVE	HOURS	HOURS
CYCLOTRON START-UP	284.0	
BEAM ON TARGET	1041.4	
TOTAL BEAM-ON TIME		1325.4
UNSCHEDULED OUTAGE		
1 ION SOURCE	10.4	
2 VACUUM SYSTEM	6.6	
3 DEMINERALIZED WATER	1.7	
4 POWER SUPPLIES	48.9	
5 R. F. SYSTEM	29.5	
6 ELECTRICAL COMPONENTS	2.0	
7 MECHANICAL COMPONENTS	10.9	
8 EXPERIMENTERS EQUIPMENT	3.7	
9 RADIOLOGICAL SAFETY	0.8	
TOTAL OUTAGE	114.5	
TOTAL SCHEDULED TIME		1436.2
PERCENT BEAM AVAILABLE (ITEM 8 INCLUDED IN BEAM-ON TIME)		92.3
TOTAL HOURS AVAILABLE TO DATE		6552.0
POSSIBLE SCHEDULED HOURS (2-SHIFTS 6-DAYS PER WEEK)		3632.0
UTILIZATION FACTOR, PERCENT		39.5

Table 5

A listing of purchases required for cyclotron facility operation

CYCLOTRON APPLICATIONS BRANCH SUMMARY OF PURCHASES
FY-79 JUNE 30, 1979

CONTROLS AND, PROGRAM OPERATIONS MONTH ALL PRICE 0 CATEGORY A ALL

ITEM		COST	PROGRAM	MONTH	CARD	STOR NO.	CATEGORY A
IBM KEYPUNCH	$	1632	OPERATIONS	OCTOBER	1	13 *	DATA SYSTEM
VYDEC	$	6391	OPERATIONS	OCTOBER	2	14 *	DATA SYSTEM
SEL SOFTWARE	$	635	OPERATIONS	OCTOBER	3	15 *	DATA SYSTEM
STAINER FILTER	$	3492	OPERATIONS	OCTOBER	5	25 *	H-2-O SYSTEM
PLASTIC TOP	$	5	OPERATIONS	OCTOBER	6	37	MATERIALS
DISC CARTRIDGE	$	192	OPERATIONS	OCTOBER	7	56 *	DATA SYSTEM
GASKET MATERIAL	$	50	OPERATIONS	OCTOBER	8	57 *	ION SOURCE
XEROX TRANSPARENCIES	$	64	OPERATIONS	OCTOBER	9	64 *	MATERIALS
DISPATCH CASE	$	10	OPERATIONS	NOVEMBER	11	77	MATERIALS
DISPATCH CASE	$	10	OPERATIONS	NOVEMBER	12	78	MATERIALS
DEUTERIUM	$	255	OPERATIONS	NOVEMBER	14	109 *	MATERIALS
POWER DEVICES	$	2617	OPERATIONS	NOVEMBER	15	112 *	POWER SUPPLIES
CARTRIDGE REGENERATION	$	1464	OPERATIONS	DECEMBER	16	120 *	H-2-O SYSTEM
FILTER MEMBRANE	$	306	OPERATIONS	DECEMBER	17	121 *	H-2-O SYSTEM
CARTRIDGE REGENERATION	$	1224	OPERATIONS	JANUARY	19	156 *	H-2-O SYSTEM
CUPS	$	16	OPERATIONS	FEBRUARY	21	221 *	MATERIALS
XEROX TRANSPARENCIES	$	60	OPERATIONS	FEBRUARY	22	220 *	MATERIALS
ALUMINUM FOIL	$	6	OPERATIONS	FEBRUARY	23	233 *	MATERIALS
B P ENERGOIL	$	256	OPERATIONS	FEBRUARY	24	245 *	VACUUM SYSTEM
CHOPPER	$	286	OPERATIONS	MARCH	26	253 *	POWER SUPPLIES
CAMERA REPAIR	$	50	OPERATIONS	MARCH	27	291 *	MATERIALS
DEUTERIUM	$	255	OPERATIONS	MARCH	28	298 *	ION SOURCE
VACUUM REPAIR KIT	$	50	OPERATIONS	MARCH	29	299 *	VACUUM SYSTEM
IONIZATION TUBES	$	420	OPERATIONS	MARCH	30	297 *	VACUUM SYSTEM
VACUUM REPAIR KIT	$	50	OPERATIONS	APRIL	31	310 *	VACUUM SYSTEM
THERMOCOUPLE TUBE	$	240	OPERATIONS	APRIL	32	309 *	VACUUM SYSTEM
MULTIDRAFT	$	18	OPERATIONS	APRIL	33	316 *	MATERIALS
CARTRIDGE REGENERATION	$	1224	OPERATIONS	APRIL	38	335 *	H-2-O SYSTEM
CHOPPER	$	206	OPERATIONS	APRIL	39	342 *	POWER SUPPLIES
MICROFICHE READER	$	307	OPERATIONS	MAY	40	353 *	MATERIALS
UPPER PART FOR READER	$	9	OPERATIONS	JUNE	42	385 *	MATERIALS
TOTAL	$	21626					

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table 5

A listing of purchases required for cyclotron facility operation

CYCLOTRON APPLICATIONS BRANCH SUMMARY OF PURCHASES
FY-79 JUNE 30, 1979

CONTROLS ARE, PROGRAM OPERATIONS MONTH ALL PRICE 0 CATEGORY A ALL

ITEM		COST	PROGRAM	MONTH	CARD	STUB NO.		CATEGORY A
IBM KEYPUNCH	$	1632	OPERATIONS	OCTOBER	1	13	*	DATA SYSTEM
VYDEC	$	6391	OPERATIONS	OCTOBER	2	14	*	DATA SYSTEM
SEL SOFTWARE	$	635	OPERATIONS	OCTOBER	3	15	*	DATA SYSTEM
STAINER FILTER	$	3492	OPERATIONS	OCTOBER	5	25	*	H-2-0 SYSTEM
PLASTIC TOP	$	5	OPERATIONS	OCTOBER	6	37		MATERIALS
DISC CARTRIDGE	$	192	OPERATIONS	OCTOBER	7	56	*	DATA SYSTEM
GASKET MATERIAL	$	50	OPERATIONS	OCTOBER	8	57	*	ION SOURCE
XEROX TRANSPARENCIES	$	64	OPERATIONS	OCTOBER	9	64	*	MATERIALS
DISPATCH CASE	$	10	OPERATIONS	NOVEMBER	11	77		MATERIALS
DISPATCH CASE	$	10	OPERATIONS	NOVEMBER	12	78		MATERIALS
DEUTERIUM	$	255	OPERATIONS	NOVEMBER	14	109	*	MATERIALS
POWER DEVICES	$	2617	OPERATIONS	NOVEMBER	15	112	*	POWER SUPPLIES
CARTRIDGE REGENERATION	$	1464	OPERATIONS	DECEMBER	16	120	*	H-2-0 SYSTEM
FILTER MEMBRANE	$	306	OPERATIONS	DECEMBER	17	121	*	H-2-0 SYSTEM
CARTRIDGE REGENERATION	$	1224	OPERATIONS	JANUARY	19	156	*	H-2-0 SYSTEM
CUPS	$	16	OPERATIONS	FEBRUARY	21	221	*	MATERIALS
XEROX TRANSPARENCIES	$	66	OPERATIONS	FEBRUARY	22	220	*	MATERIALS
ALUMINUM FOIL	$	6	OPERATIONS	FEBRUARY	23	233	*	MATERIALS
H P ENERGOIL	$	256	OPERATIONS	FEBRUARY	24	245	*	VACUUM SYSTEM
CHOPPER	$	286	OPERATIONS	MARCH	26	253	*	POWER SUPPLIES
CAMERA REPAIR	$	50	OPERATIONS	MARCH	27	291	*	MATERIALS
DEUTERIUM	$	255	OPERATIONS	MARCH	28	298	*	ION SOURCE
VACUUM REPAIR KIT	$	50	OPERATIONS	MARCH	29	299	*	VACUUM SYSTEM
IONIZATION TUBES	$	420	OPERATIONS	MARCH	30	297	*	VACUUM SYSTEM
VACUUM REPAIR KIT	$	50	OPERATIONS	APRIL	31	310	*	VACUUM SYSTEM
THERMOCOUPLE TUBE	$	240	OPERATIONS	APRIL	32	309	*	VACUUM SYSTEM
MULTIGRAFT	$	18	OPERATIONS	APRIL	33	316	*	MATERIALS
CARTRIDGE REGENERATION	$	1224	OPERATIONS	APRIL	38	333	*	H-2-0 SYSTEM
CHOPPER	$	206	OPERATIONS	APRIL	39	342	*	POWER SUPPLIES
MICROFICHE READER	$	307	OPERATIONS	MAY	40	353	*	MATERIALS
UPPER PART FOR READER	$	9	OPERATIONS	JUNE	42	385	*	MATERIALS
TOTAL	$	21626						